Data communication I

Lecture 1 – Course Introduction

About the course…

- Basics of datacommunication
  - How is information transported between digital devices?
  - Essential data communication protocols
- Insight into computer networking
  - What types of networks are common today?
  - What are their requirements (in terms of equipment, perfomance etc.)?
  - Essential networking protocols.

Staff involved in the course…

- Annette Böhm
  - PhD candidate and lecturer
  - In this course:
    - Course responsible, lecturer, contact person for any kinds of questions regaring the course
  - Contact information:
    - annette.bohm@hh.se
    - Room E315
- Jerker Bengtsson
  - Lab assistant

Course Homepage

- http://www.hh.se/dk6001
- http://www2.hh.se/staff/krku/annette/dk6001.html

Course structure

- Course language:
  - English with some elements of swedish
- Structure:
  - 12 lectures (à 2 h)
  - 2 labs (à 4 h)
  - Written exam

Examination

- Lectures
  - Not mandatory
  - But VERY valuable source of knowledge!
- Laboration excercises
  - Mandatory!
  - You need to pass the 2 labs to get a final grade for the course
  - You work in groups of 2 students
- Written exam
  - Grades: fail, 3, 4, 5.

More about the written exam

- General information
  - Language: english, swedish or german
  - Time frame: 4 hours
  - Just blank paper and pen allowed!
- Type of questions:
  - Essay questions of various length
  - Test your general understanding of methods and principles rather than the ability to learn terminology by heart!

- Course prerequisites
  - Some programming skills
  - Basic mathematics
- How to succeed with the course?
  - Attend lectures
  - Read course literature prior to or directly after the related lecture
  - Don’t get lost in the details right away, but focus on the general picture

Course Literature

- Stallings, W., ”*Data and Computer Communications”*. 7th (or 8th) edition, Prentice-Hall, Inc., Upper Saddle River, NJ, USA, 2004,

  (ISBN 0-13-183311-1).

- ”Handouts”

  (available on the course homepage prior to lecture 10)

Course contents

- Lecture 1
  - Course introduction
  - Introduction to the subject
    - Basic terminology
    - Binary number system and addressing
    - OSI and TCP/IP reference models
  - *Stallings: chapter 1 (all), chapter 2 (all)*

Chapter 1 (all) -> 10 pages
Chapter 2 (not App. 2A) -> 25 pages

- Lecture 2
  - Layer 1 concepts (Physical Layer)
    - Digital and analog data and transmission
    - Transmission media

Chapter 3 (all) -> 35 pages
Chapter 4 (all) -> 30 pages

- Lecture 3
  - Layer 1 concepts (Physical Layer) cont.
    - Data encoding
  - Layer 2 concepts (Link Layer)
    - Flow control
    - Error control

Chapter 5 (5.1-5.3) -> 30 pages
Chapter 6 (6.1-6.5) -> 22 pages
Chapter 7 (7.1-7.2) -> 15 pages

Course contents

- Lecture 4
  - Layer 2 concepts (Link Layer) cont.
    - Multiplexing
    - Medium Access Control

Chapter 8 (8.1-8.3) -> 20 pages

- Lecture 5
  - Repetition part I
- Lecture 6
  - Concepts of Wide Area Networks
    - Packet vs circuit switching
    - Example technologies

Chapter 10 (all) -> 35 pages
Chapter 11 (11.1-11.2) -> 7 pages

- Lecture 7
  - Layer 3 concepts (Network Layer)
    - Routing
  - Layer 4 concepts (Transport Layer)
    - Congestion control

Chapter 12 (all) -> 23 pages
Chapter 13 (13.1-13.4) -> 11 pages

Course contents

- Lecture 8
  - Concepts of Local Area Networks
    - Topologies
    - Networking devices
  - High-Speed LANs

Chapter 15 (all) -> 30 pages
Chapter 16 (16.1-16.3) -> 20 pages

- Lecture 9
  - The Internet and TCP/IP
    - Internetwork Protocols
    - Transport Protocols

Chapter 18 (all) -> 40 pages
Chapter 20 (all) -> 40 pages

- Lecture 10
  - Other types of networks
    - Optical networks
    - Wireless networks

Compendium

- Lecture 11
  - Repetition of part II
- Lecture x
  - Introduction to the laboratory exercises

So why data communications?

”There is no reason for any individual to have a computer in his home.”
Ken Olsen (president Digital Equipment Corporation), 1977

Today:

- PC in ”every” home
- 60 computers in a modern car
- Etc.

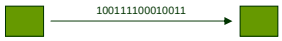
- Huge need to interconnect devices and exchange data between them!

So why data communication?

- Transfer of digital (and analog) data between devices/entities
  - Wireless vs wired
  - Point-to-point vs large networks
  - Large scale (e.g. Internet) vs tiny scale (e.g. embedded systems)
- Different physical and performance requirements but still common principles

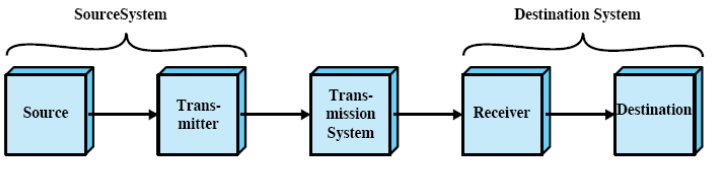
Data communication vs. networking

- Data communication
  - How is data transfered between 2 (or more) nodes?
  - Does not imply the existence of a whole ”network”

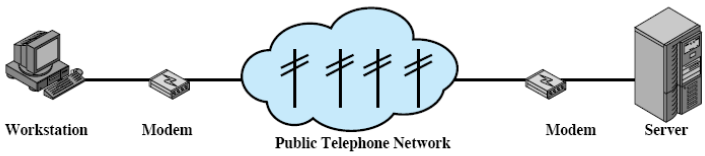


- Computer networking
  - How is a network of multiple nodes organized?
  - How is the communication over this network organized?

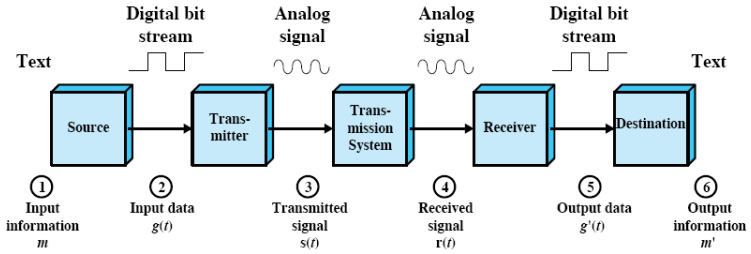
Simple data communication model



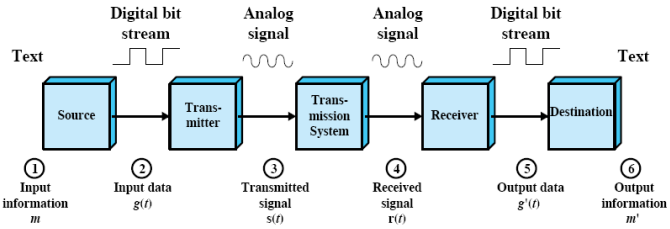
(a) General block diagram



(b) Example



- Input information should be the same as output information!
  - *m=m', g(t)=g'(t), s(t)=r(t).*
  - *Common rules needed between source and destination*
  - *Common rules needed between transmitter and receiver*
  - *Strategies needed to handle data loss or errors in the transmission system*



- Input information should be the same as output information!
  - *m=m', g(t)=g'(t), s(t)=r(t).*
  - *Common rules needed between source and destination*
  - *Common rules needed between transmitter and receiver*
  - *Strategies needed to handle data loss or errors in the transmission system*

Protocols

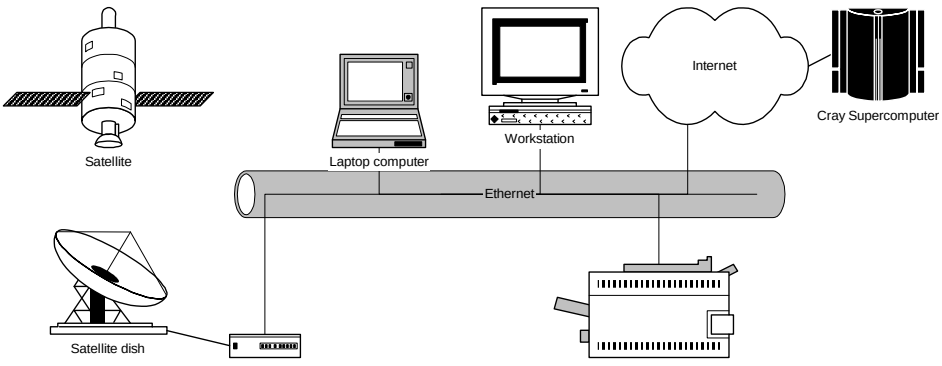
Protocol

- A protocol is a set of common rules used by computers (communicating devices) to manage the tranfer of data.

” There are no fundamental differences between data processing and data communication and no fundamental differences between data, voice and video communication.”

William Stallings

Communication networks



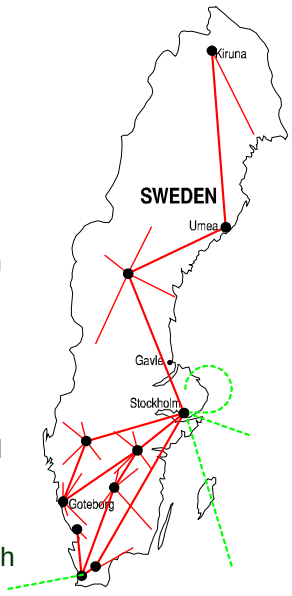
Network types

Node distance	Size	
10 m	Room	LAN (Local Area Network
100 m	Building	
1 km	e.g. Campus	
10 km	City	MAN (Metropolitan)
100 km	Country	WAN (Wide Area Network)
1 000 km	Continent	
10 000 km	Planet	Internet

WAN (Wide Area Network)

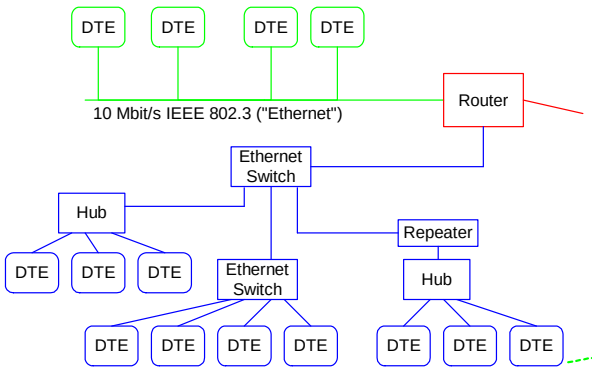
- **Circuit switching**
  - A connection between source and destination is established prior to the communication
  - Bandwidth is reserved for the duration of this connection
  - E.g. telephone call over the telephone networks

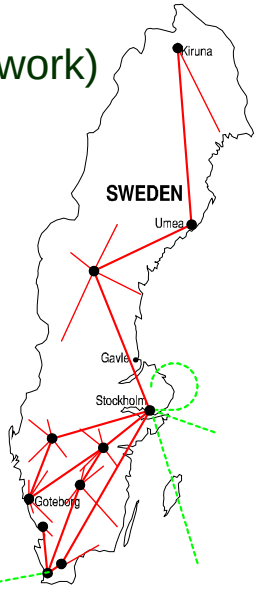
- **Packet switching**
  - No end-to-end connection established
  - Data is sent in small chunks (packets) over the network
  - Each packet might take a different path through the network



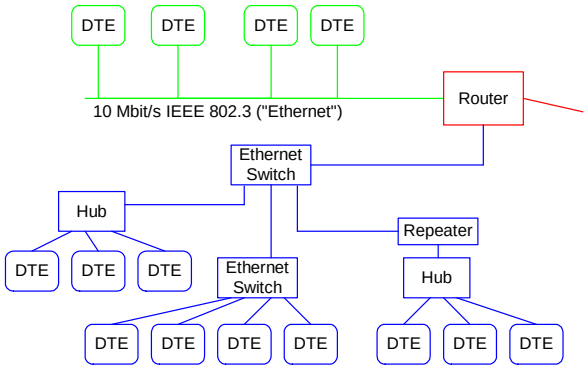
WAN (Wide Area Network)

LAN (Local Area Network)



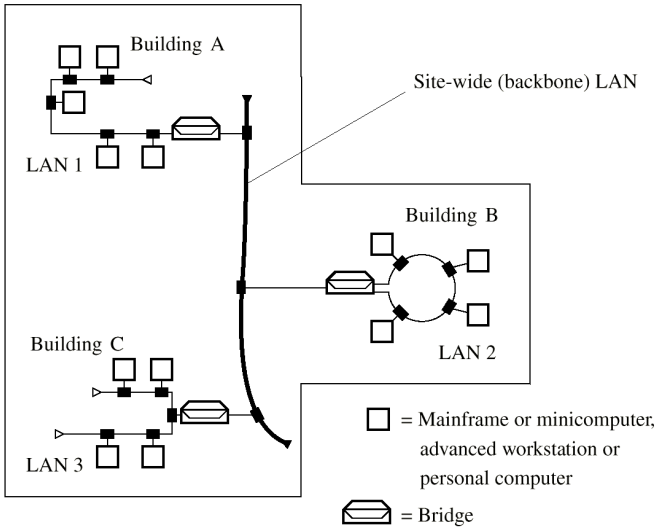


LAN (Local Area Network)



- DTE=Data Terminating Equipment, e.g. a PC.
- Router, Switch, Hub, Repeater are networking equipment (explained later in the course
- Ethernet is a networking technology for LANs (touched upon later in the course)

LAN (Local Area Network)



”Binary”: The common language of data communication

Decimal	Binary
0	00000000
1	00000001
2	00000010
3	00000011
4	00000100
5	00000101
6	00000110
7	00000111
8	00001000
9	00001001
10	00001010
11	00001011
12	00001100

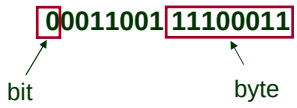
- Everything (text, voice, video etc.) is translated into binary digits (1 and 0)
- Our number system (decimal system) is based on 10 symbols: 0-9
- The binary system uses only 2 symbols: 0 and 1.
- Even letters and words are expressed in binary through e.g. the ASCII code.

ASCII Code: Character to Binary

- "Hello"
  001100101011011
  000110110001101
  111
- "See you!"
  010100110110010
  101100101001000
  001111001011011
  110111010100100
  001

0	0011 0000	O	0100 1111	m	0110 1101
1	0011 0001	P	0101 0000	n	0110 1110
2	0011 0010	Q	0101 0001	o	0110 1111
3	0011 0011	R	0101 0010	p	0111 0000
4	0011 0100	S	0101 0011	q	0111 0001
5	0011 0101	T	0101 0100	r	0111 0010
6	0011 0110	U	0101 0101	s	0111 0011
7	0011 0111	V	0101 0110	t	0111 0100
8	0011 1000	W	0101 0111	u	0111 0101
9	0011 1001	X	0101 1000	v	0111 0110
A	0100 0001	Y	0101 1001	w	0111 0111
B	0100 0010	Z	0101 1010	x	0111 1000
C	0100 0011	a	0110 0001	y	0111 1001
D	0100 0100	b	0110 0010	z	0111 1010
E	0100 0101	c	0110 0011	.	0010 1110
F	0100 0110	d	0110 0100	,	0010 0111
G	0100 0111	e	0110 0101	:	0011 1010
H	0100 1000	f	0110 0110	;	0011 1011
I	0100 1001	g	0110 0111	?	0011 1111
J	0100 1010	h	0110 1000	!	0010 0001
K	0100 1011	I	0110 1001	'	0010 1100
L	0100 1100	j	0110 1010	"	0010 0010
M	0100 1101	k	0110 1011	(	0010 1000
N	0100 1110	l	0110 1100	)	0010 1001
				space	0010 0000

- 1 bit = the smallest digital data entity (0 or 1)
- 1 byte = 8 bits
- Several bytes make up a frame
- Several frames make up a message
- **"Fragmentation"** = to cut a stream of data (bits) into manageable chunks that can be handled by networking devices and data communication protocols



To measure data rate ("bandwidth"):

- bps (bits per second)
- Kbps (kilobits per second = 1000 bps)
- Mbps (megabits per sec = 1 000 000 bps)
- Gbps (gigabits per sec = 1 000 000 000 bps)

To measure e.g. file or memory size:

- Byte (= 8 bits)
- Kbyte (= 1000 byte)
- Mbyte (= 1 000 000 byte)
- Etc.

Protocol architecture

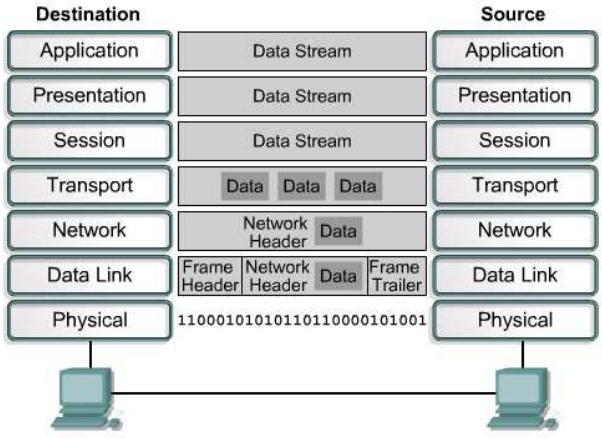
- Layered structure of hardware and software
- Each layer:
  - implements one or more protocols
  - is responsible for a subset of tasks needed for successfull communication
  - provides services to the layer above or below
  - hides details of its subtasks from the layer above or below
- Examples:
  - OSI reference model
  - TCP/IP protocol suite (widely used)

- A coresponding set of layers exist in both source and destination
- The coresponding layers need to apply matching protocols
- Generally communication involves 3 agents: applications, computers, network.

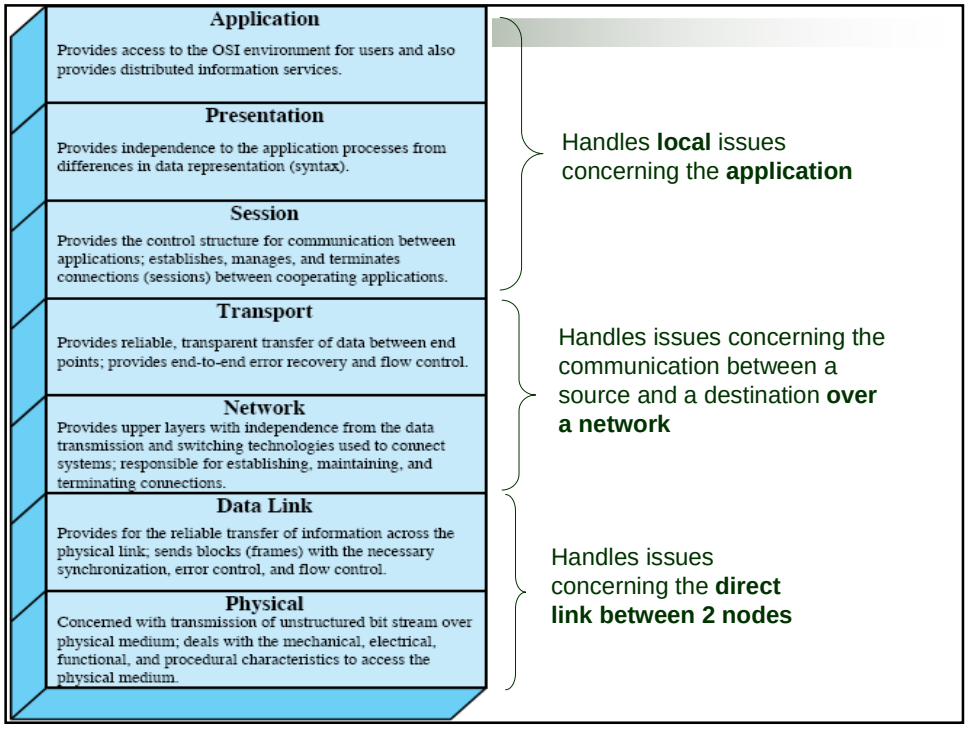
- A coresponding set of layers exist in both source and destination
- The coresponding layers need to apply matching protocols
- Generally communication involves 3 agents: application, computers, network.

Standards needed

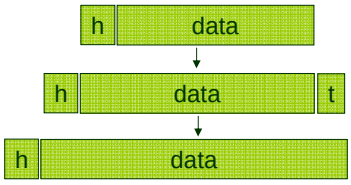
The OSI reference model

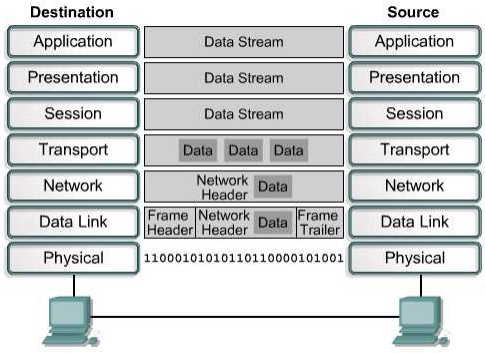


- OSI (Open Systems Interconnection)
- 7 layers

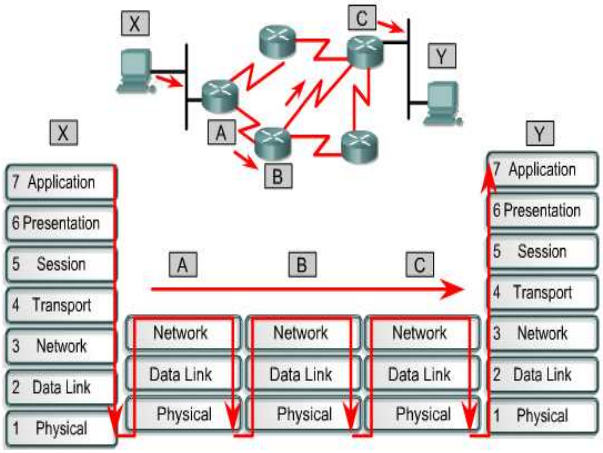


Encapsulation



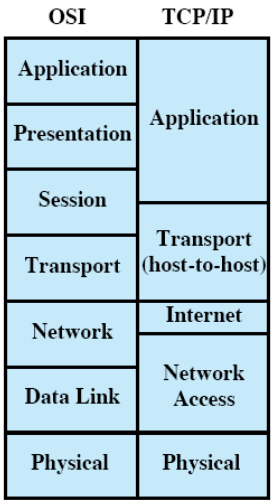


- Chunks of data are passed down through the layers
  - →Fragmentation
- Every layer adds its information in front of (header) and/or behind (trailer)
  - →Encapsulation
- The more layers, the more extra ”administrative” data (overhead)

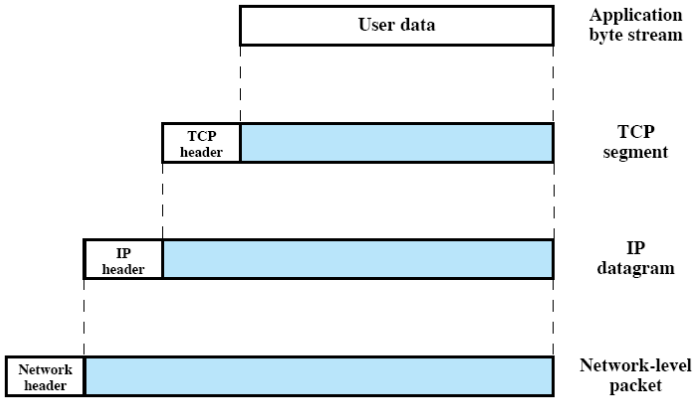


- Intermediate networking devices (e.g. routers) only move up the layers (and ”unpack” the data) as long as needed to perform their tasks!

The TCP/IP protocol stack



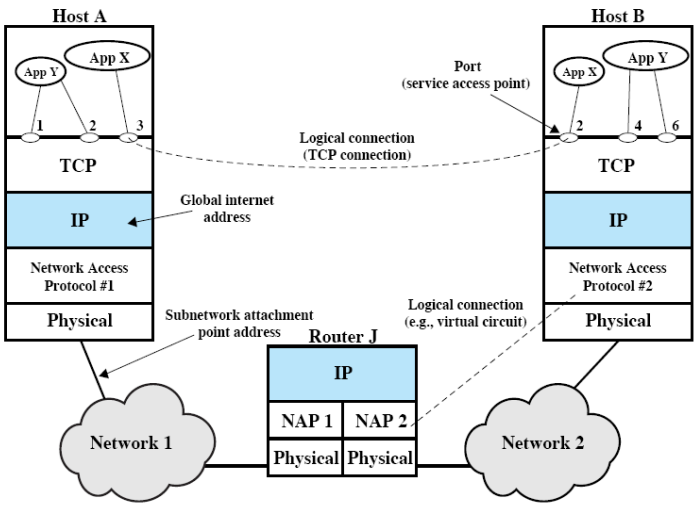
- Collection of protocols issued as Internet Standards
- 5 layers
  - Physical layer
    - Transmission medium, signals, data rate etc.
  - Network layer
    - Network-related tasks, addressing
  - Internet layer
    - Routing through the network
  - Transport layer
    - End-to-end reliability
  - Application layer



- IP protocol on the internet layer
- TCP or UDP protocol on the transport layer

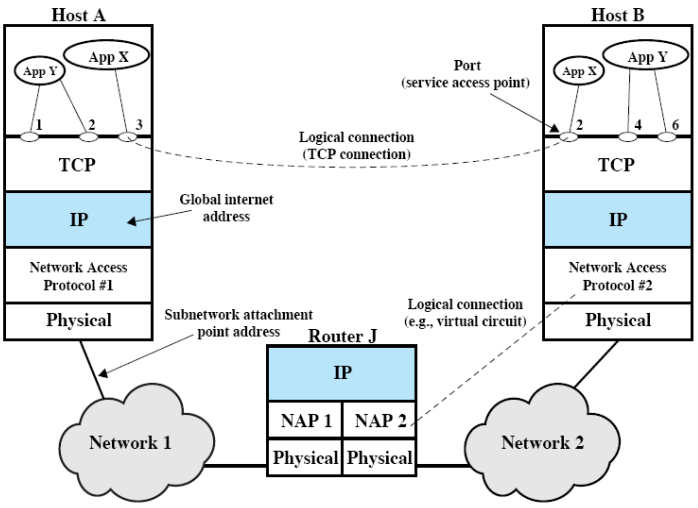
TCP vs. UDP

- TCP (Transmission Control Protocol)
  - provides reliable connection (→"connection oriented")
  - Each application is associated with a port
  - A source port is associated with a destination port to establish a connection
  - TCP keeps track of the sent and received data packets, regulated the flow and recoveres erroneous packets
  - High reliability
- UDP (User Datagram Protocol)
  - Does not establish a connection (→"connectionless")
  - Does not keep track of the data packets
  - Low reliability

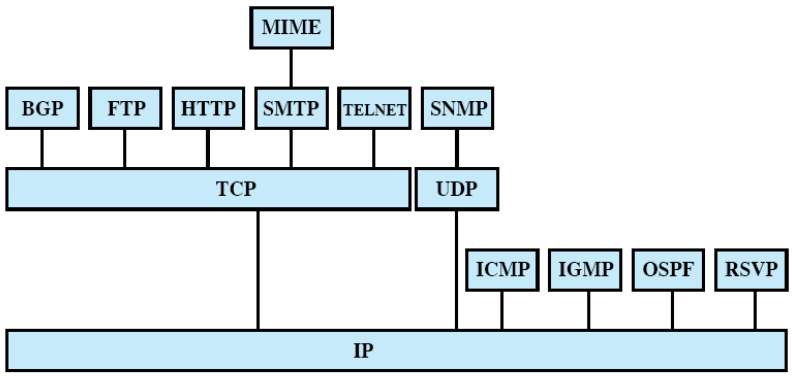


- IP implemented in all intermediate networking devices
- TCP is only implemented in the end systems

- Global addresses (IP addresses) identify each networking device within the Internet
- Ports identify each process within the end nodes



Common Internet applications



BGP = Border Gateway Protocol
FTP = File Transfer Protocol
HTTP = Hypertext Transfer Protocol
ICMP = Internet Control Message Protocol
IGMP = Internet Group Management Protocol
IP = Internet Protocol
MIME = Multipurpose Internet Mail Extension
OSPF = Open Shortest Path First
RSVP = Resource ReSerVation Protocol
SMTP = Simple Mail Transfer Protocol
SNMP = Simple Network Management Protocol
TCP = Transmission Control Protocol
UDP = User Datagram Protocol

What classifies a network?

What classifies a network?

- How many nodes are in the network?
- What distances are covered?
- How fast is the data transfered?
- How expensive is it to transfer data?
- How much data is transfered per time unit?
- How reliable is the transfer?
- How are the nodes interconnected?
- Over what medium is the data sent?

What classifies a network?

- How many nodes are in the network?
  - **Scalability**
- What distances are covered?
- How fast is the data transfered?
  - **Delay, latency**
- How expensive is it to transfer data?
- How much data is transfered per time unit?
  - **Throughput**
  - **Bandwidth**
- How reliable is the transfer?
- How are the nodes interconnected?
  - **Topology**
- Over what medium is the data sent?

Key terms

- Local Area Network (LAN)
- Wide Area Network (WAN)
- Communication Protocol
- Transmitter vs. Receiver
- Source vs. Destination
- Transmission Medium
- OSI reference model (”OSI stack”)
- TCP/IP reference model (”TCP/IP-stack”)
- Fragmentation
- Scalability
- Bandwidth
- Throughput
- Latency, delay
- Topology
- Encapsulation
- Header and trailer
- Overhead
- Connection oriented vs. connectionless
- IP addresses
- Port numbers
- Packet switching vs. circuit switching
- Binary number system
- Layer

Extra slide: Switching techniques comparison

Item	CS	PS
Call setup	Required	Not needed
Physical path	Yes	No
Bandwidth available	Fixed	Dynamic
Packets arrive in order	Yes	No
Possible congestion time	At setup	Every packet
Each packet follow same path	Yes	No
Switch crash fatal	Yes	No
Store-and-forward	No	Yes
Waste of bandwidth (potentially)	Yes	No
Charging	Per minute	Per packet

CS = Circuit Switching, PS = Packet Switching